NAVY RED HILL TANK FARM ACTIVITIES SCOPE ITEMS 6 & 7
COMMENTS FROM HDOH and EPA - January 19, 2018

Preface: These notes are compiled from comments by the EPA and HDOH and their technical staff and contractors. Brevity and specificity are the goals of this condensation, and not all of the available comments are included here, but may be incorporated as deemed useful by the managers. Overall the Navy has been diligent in its work efforts and much good work has been completed; this comment suite will focus of critical issues and not belabor that we recognize the good work has done to date. The purpose of our comments is to better focus the Navy's efforts on protection of the groundwater resource.

REGULATORY POSITION SUMMARY

The HDOH and EPA disagree technically and philosophically with important elements of the current Navy Red Hill conceptual site model (CSM) and its preliminary conclusions ***(1)***. The Navy's CSM is not conservative, nor does it recognize or account for past and existing impacts to groundwater beneath the Tank Farm and at Red Hill Shaft. The CSM seems to digress from the Navy work plans pertaining to its development ***(2)***, most of the elements of which we concur are necessary, although perhaps at a finer scale than planned. The CSM suffers from broad, sweeping assertions of a generally protective subsurface environment when in fact actual site data and technical literature from analogous sites suggest the opposite probability. The Navy often focuses on relatively unimportant technical matters and ignores or defers more critical facets of the CSM and groundwater protection. It is the general opinion of the EPA/HDOH technical reviewers that the Navy needs to focus more clearly on detailed conditions near and around Red Hill ridge and demonstrate that understanding and risk potential before moving to efforts further afield. At every step of the process, the Navy's evaluations need to be consistent with and fully consider ***all*** available site specific data; presently the CSM appears to ignore existing data that suggest the potential for groundwater threats and elaborates primarily on data that appear protective (i.e., a non-conservative analysis) ***(1)***. Where data are absent or site conditions unknown, conservative (i.e., worst-case protective assumptions) need to be used, as requisite to all credible risk evaluation methodologies. Alternatively, data can be collected to address those gaps in and around the Red Hill Tank Farm (RHTF). In short, impacts to the sole source aquifer and at Red Hill Shaft have already occurred, the Navy's CSM minimizes those and erroneously concludes (to date) there is no likely risk from reasonable future releases (also undefined).

The remainder of this comment review will discuss three related areas of the CSM and ongoing evaluations: 1) Data collection; 2) Groundwater modeling; and 3) LNAPL modeling. Each discussion will begin with some general observations, followed by specific suggestions for improvement.

DATA EVALUATIONS & COLLECTION

The Navy's baseline data collection and literature review plan is generally reasonable ***(2)***, but like the overview of the CSM above, suffers from a wide-area implementation under the implicit assumption that near-field (i.e., Red Hill Tank Farm *[RHTF]*) conditions are understood with

sufficient certainty. The Navy's data gap analysis suggests that better understanding of contaminants in groundwater is a secondary data gap ***(3)***; we disagree. Understanding the distribution of past and current impacts is an important component of the CSM, without which we cannot hope to understand realistic fate and transport (F&T) conditions. In general, the absence of sufficiently dense data in and around RHTF is the most significant gap; it is too late to in-fill the chronologic record, but local area understanding can be improved. In particular, the character, continuity, interconnectivity and transport properties of the geologic bedding beneath the Red Hill Tank Farm (RHTF) need better resolution and documentation. Although this is discussed by the Navy ***(2)***, there is no pertinent data collection effort around the RHTF.

The first priority in support of the CSM and derivative modeling and evaluations is a clear, definitive and comprehensive evaluation of subsurface geologic conditions to include in three dimensions (3-D): a) lithology, bedding, fracture character, continuity, and geometry; b) petrophysical and parametric characteristics of those geologic horizons; c) better assessment of past and present plume conditions that have reached as far as the Red Hill Shaft monitoring well; and d) from the preceding steps, a local area fuel and dissolved-phase transport analysis. These aspects are directly or indirectly noted in ***(2)***, but it is unclear how these determinations will be made absent additional data. It appears the Navy has built a 3-D geologic model based on available boring and barrel logs in the RHTF area. That should provide a good foundation to the additional details the reviewers would like included (or to be provided with if completed). We would like to see detailed evaluations of strike/dip of bedding and fracture sets, the interpreted geometry and connectivity of those zones, and other relevant features of these differing geologic units. Within that evaluation we would expect an analysis of variance and uncertainty. In both the Navy's current groundwater and LNAPL models, there is an inherent assumption of continuity and that these discrete conditions can be treated as an equivalent porous media (EPM). That assumption is non-conservative and presently unvalidated by the detailed mapping and geologic evaluations indicated above. If this has been completed already by the Navy team, that information needs to be provided to the EPA and HDOH technical team for review.

Once a stronger local area CSM is constructed (or presented, if available), the logical next step would be testing that model with continuity tests that demonstrate the connectivity and dimensions of geologic units in continuity with potential release points. Those may include: 1) Aqueous &/or vapor tracer tests; 2) Hydraulic &/or pneumatic continuity testing; 3) Temperature and conductivity profiling; and 4) Geophysical testing (existing and augmented). To do any of these, sufficient local area sampling locations would be needed. Absent these types of data collection and testing efforts, the Navy CSM ***must*** assume high interconnectivity of fractures/bedding and in at least some worst-case configurations. For example, absent proof otherwise, the CSM should assume that bedding planes and continuity orientations allow rapid transport of contaminants from the RHTF to the sole source aquifer and receptors therein, as already suggested by existing and historic groundwater impacts.

In keeping with above, the other aspects of the Navy CSM would benefit substantially by further data collection in and around the RHTF. Presently, the only new location near the RHTF is proposed well RHMW01R adjacent to an already investigated location and about 600-ft from the Tank 5 release area. As presented by the Navy at the January 11, 2018 meeting, the CSM does not recognize the existing/historic impacts within the aquifer and the single new replacement

well location will do little to resolve that gap. A more tightly spaced monitoring network would assist in refining those critical elements of the CSM as well as acting as better near-source sentry well locations. It is recommended that the Navy consider at least 6 new borings/monitoring well locations within the actual footprint of the RHTF (between tank alignments and immediately outside). These can be standard monitoring wells to augment the more advanced Westbay multi-level wells installed at other locations, or they can be Westbay installations. Cores should be photo-logged and selected intervals tested for petrophysical and chemical conditions (see below).

Finally, there is a partial absence of site specific characterization of the full suite of properties and parameters that control the fate and transport of the jet fuels and associated dissolved- and vapor-phase impacts. Again, this gap is most prevalent with respect to hydrogeologic properties in and around RHTF. These include: a) lateral and vertical hydraulic conductivity and its variation; b) capillary retention testing of porous and fractured media; c) fracture aperture analysis; d) residual saturation testing under drainage conditions; e) jet fuel physical properties, particularly interfacial tension, viscosity, and chemical speciation; f) bench or field scale NAPL percolation testing. These properties and characteristics are typically sensitive parameters in modeling or other evaluations of LNAPL and contaminant transport.

GROUNDWATER MODELING COMMENTS

The groundwater modeling effort is of high quality in many respects. However, the key elements missing in the evaluations to date follow the concerns above regarding the CSM and its presently non-conservative status. The model implicitly assumes potential large scale interconnectivity of geologic units as an equivalent porous medium (EPM). There are many studies from other similar basalt regions indicating a high potential for connected, preferential flow-paths that can enhance the distance and reduce the time for migration versus idealized, EPM-type systems and assumptions. Even simple conditions, like the Borden contaminant study site in Canada, show plumes distribute heterogeneously under even ideal conditions. Site specifically, the distribution of highly variable gradients local to the RHTF (e.g., pages 29 - 32, ***(1)***) and the broad historic distribution of chemical impacts to groundwater ***(4)*** together suggest the hydrogeologic system is far more complicated and inherently less protective than the Navy's groundwater model suggests to this point. This also suggests that the model may be incorrect even with its derivation of primary groundwater flow directions to the Southwest, at least relative to the scale of the RHTF.

The water level mapping presented to-date in support of the model is useful in general terms, but could be more informative if approached with more rigor. For example, water level mapping can be used to test hypotheses in the area of the RHTF by evaluating the role that a potential high-transmissivity feature would have on the groundwater gradient and making related water balance calculations. Alternatively, residuals from the water level mapping can help identify areas of particularly strong departure from the underlying conceptual site model that can point to heterogeneity, stresses, and other features that warrant inclusion and perhaps rescaling within the groundwater model

The groundwater model appears to use existing literature sources to prescribe general head boundaries (water flow input) to the model that are themselves calibration parameters. These

types of boundaries have a strong effect on model predictions and calibration and should be well justified through related hydrogeologic analysis. In other words, these boundaries can and should be independently estimated from hydrogeologic information. Incorrect boundaries may exert too strong an influence on flow and migration patterns, acting to enhance or over-prescribe the propensity for flow to occur from mountains to lowlands regardless of other factors (recharge rates, pumping, etc.). This boundary condition in particular (although in concert with the lateral boundaries) should be viewed with caution and evaluated via calibration-constrained sensitivity analyses.

The groundwater mound and recharge in the area of the Halawa quarry are not likely critical to the modeling analysis and are in any case non-conservative at this point. While infiltration from the quarry is one possibility, so is diffuse stream recharge through the lower permeability saprolites estimated at approximately 10-inches per year. A water balance analysis in this area would help resolve what recharge inputs are important (or not) to the model. In any case, neither condition likely prevents flow beneath that zone through the deeper aquifer basaltic units which is the more important technical consideration. The Navy team seems to be focused on what it believes is a natural protective barrier, while the regulatory team has seen insufficient demonstration of that. We believe the modeling team, at the January 11, 2018 meeting, confirmed that modeled groundwater flow by-passes beneath this unit, as would be expected. Given that there have been historic impacts to the deep Halawa monitoring well on the opposite side of that nearby saprolitic wedge (and not withstanding its sampling imperfections), one must assume that these saprolites are not inherently protective as directly indicated by the available data. Again, the Navy team has not, in our view, put together a comprehensive and conservative analysis that recognizes all available data and the likely non-protective nature of this area.

While the 3-D RHTF geologic model in-progress appears relatively complex (though unparameterized as this point), the broader geologic model in the groundwater model does not. As best the reviewers can understand, it represents essentially only major Hydrostratigraphic Units (HSUs) that differentiate basalt from saprolite from carbonates, fill, etc. There appears to be no differentiation within these first-order HSUs, and therefore their reliability as a predictive tool is in question. There are methods available that are suitable for representing basalt sequences like those at Red Hill and beyond for this purposes. It is however unclear how and to what extent this level of HSU differentiation will be incorporated in the final groundwater model. Evaluations by the Navy team supporting the HSU simplifications are necessary, as is a road map for what final level of detail will likely be considered or eliminated as unnecessary based on appropriate evaluations.

It is unclear if the current groundwater model incorporates new data associated with the CSM. It would help when the model is being presented for this to be made clear. In other words, the reviewers have too little advance information to assess the assumptions being made in the modeling work and their consistency with field data.

Finally, it is unclear how the groundwater model will transition from its current state as essentially a large-scale water budget model to more detailed evaluations of contaminant fate and transport and aquifer protection. If the model simplifications above remain, the reviewers believe F&T results will be uninformative and likely non-conservative. Again, if one

conservatively assumes, as we believe the Navy should, that documented impacts at the Red Hill Shaft monitoring well are from the RHTF, then the plume has traveled approximately 2,700 feet. Nothing in the Navy's modeling or CSM presentations to date make the connection to that simple and concerning observation. Fundamentally, the Navy F&T modeling must be calibrated to and consistent with all known and potential risk/impact conditions. To present, that is not so.

LNAPL EVALUATION COMMENTS

We do not view the LNAPL evaluations presented on January 11, 2018 to represent what one could describe as a model because critical dynamic processes were not considered and the evaluation do not comport with available data. It was essentially an encapsulation of a single parametric factor (residualization) that, while relevant, is not informative to the processes that influence LNAPL migration under varying transient release conditions. As such, it is non-conservative and fails to recognize that LNAPL impacts have likely already reached groundwater in the past and at release volumes vastly smaller than those the Navy LNAPL evaluations considered "safe". There are several lines of evidence that support this observation, including: 1) LNAPL in some soil samples at significant depth beneath the RHTF; 2) Near effective solubility concentrations in groundwater at certain times/locations; 3) LNAPL "blebs" and sheens noted in groundwater. While it seemed that the Navy technical team attempted to argue away these actual data observations, the more technically sound and protective approach is to accept them as real; after all, that is why we collect data. If one does so, it is clear the present LNAPL evaluation approach has no value due to its non-representative, non-conservative framing and neglect of important multiphase processes.

The absence of geologic continuity evaluations discussed previously, the absence of any site specific parameters, and neglecting the transient transport processes of multiphase mechanics together render the Navy's current approach as non-useful. A better approach would be to complete the geologic and continuity model and verification, and then use that and the associated parameters as the input basis for multiphase transport modeling using a 2- or 3-phase numerical model that accounts for the major processes. As a suggestion, MAGNAS3 is such a code, and its application would have the benefit of one of its authors being present on the Navy team (Dr. Sorab Panday).

Based on the site data in total, and facets mentioned above, we believe the LNAPL and groundwater plumes are presently undelineated. As such, the Navy team needs to consider conservative plume distribution and release scenarios that fully comport with the existing data. This is perhaps most critical in the LNAPL migration evaluations, where in other similar settings, NAPL moves quickly and in unpredictable ways. This should be no surprise to the Navy in that within the available data, the 2014 LNAPL release and its final distribution conditions remain fully unknown. The EPA and HDOH believe that until actual data and evaluations based on those are complete, a much more conservative LNAPL migration evaluation approach is necessary and the Navy should consider LNAPL itself as a principle contaminant of concern until and unless proven otherwise.

Of particular interest to LNAPL migration is the character and connectivity of A'a clinker zones to other features like bedding planes, gas pockets, fracture sets, etc. We would also like to see

some field and petrophyisical testing of those zones, as noted above. From an LNAPL transport perspective, we expect the A'a clinker zones to behave as a permeable but heterogeneous unit due to its wide range of porosity and pore throat dimension. In other words, LNAPL will not likely flow as a uniform slug through these zones, but rather in heterogeneous fingers. While that is simply a working hypothesis, it is one we expect the Navy team to explore as it has specific impact on the rate and distance of LNAPL transport and the buffering capacity of the subsurface system.

Finally, we suggest a reframing of the key question being asked of the LNAPL evaluations to something like: "For a range of plausible release scenarios placed within the site specific detailed geologic setting, which conditions impact groundwater and of those, which potentially impact known/existing receptors?" The Navy team essentially asked "How much volume can be released without an expected impact?" That is not, in the agency view, a risk protective framing of the questions to be addressed. Again, impacts are already present as much as 2,700-ft from the RHTF, and the Navy's LNAP and contaminant F&T evaluations must embrace this and other subsurface realities and probabilities.

CITATIONS

(1) January 11, 2018. *Groundwater Flow Model Working Group Meeting No. 7, Red Hill Bulk Fuel Storage Facility*. Slide handout materials pp. 1 - 150.

(2) September 1, 2017, Revision 00. *Conceptual Site Model Development and Update Plan, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility.* Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2.

(3) April 2017, Revision 00. *Data Gap Analysis Report, Investigation and Remediation of Releases and Groundwater Protection and Evaluation, Red Hill Bulk Fuel Storage Facility.* Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. Administrative Order on Consent in the Matter of Red Hill Bulk Fuel Storage Facility, EPA Docket Number RCRA 7003-R9-2015-01 and DOH Docket Number 15-UST-EA-01, Attachment A, Statement of Work Section 6.2, Section 7.1.2, Section 7.2.2, and Section 7.3.2.

(4) July 2017, Final. Second Quarter 2017 - Quarterly Groundwater Monitoring Report Red Hill Bulk Fuel Storage Facility. Joint Base Pearl Harbor-Hickam, O'ahu, Hawai'i. DOH Facility ID No.: 9-102271, DOH Release ID Nos.: 990051, 010011, 020028, and 140010.